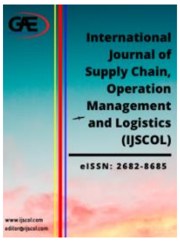
International Journal of Supply Chain, Operation Management and Logistics
EISSN: 2682-8685
Volume 3 Issue 5 (March 2022) PP. 14-25
DOI 10.35631/IJSCOL.35002



INTERNATIONAL JOURNAL OF SUPPLY CHAIN, OPERATION MANAGEMENT AND LOGISTICS (IJSCOL)
www.ijscol.com

GENERALIZED COST OF FREIGHT MULTIMODAL SYSTEM IN JAVA

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Article Info:

Article history:
Received date: 19.01.2022
Revised date: 07.02.2022
Accepted date: 02.03.2022
Published date: 06.03.2022

To cite this document:

Suryawati, L. T., Nahry., Indriastiwi, F., & Hadiwardoyo, S. P. (2022). Generalized Cost Of Freight Multimodal System In Java. *International Journal of Supply Chain, Operation Management and Logistics, 3* (5), 14-25.

DOI: 10.35631/ IJSCOL.35002

Abstract:

The multimodal system in Indonesia requires development in order to create a more efficient and reliable freight transport and diminish the domination of road transport, i.e. trucks. The utilization of more than one mode in a multimodal system, where there is a door-to-door element, requires a network development concept that refers to the use of generalized costs, instead of costs incurred to use the system (out of pocket). Generalized cost is the concept of monetization of time, distance and cost variables into a certain unit value (time or cost). The aim of this study is to analyze the generalized cost model of freight transport in Java based on truck, train and ship modes. In this paper, the generalized cost variable used is based on the viewpoint from freight forwarders and shippers obtained through primary surveys and the AHP method cost, reliability and lead time. Monetization of reliability and lead time variables on costs is based on a stated preference survey, the results of which show that the truck mode has a time VOR Rp 1,181,771 and VOT Rp 174,079 (per delivery per hour). These values are the largest compared to the other modes considering that congestion and the unavailability of adequate infrastructure are the factors that cause delays. The results of the generalized cost show that the ship mode, which has the largest generalized cost value, is 1.29 times more expensive than the truck mode considering that the journey is heavily influenced by weather and has a need for further modes to the destination as well as additional handling equipment which increases transportation costs. The outcome are expected to be used by the government as a reference in determining multimodal transport development policies which will enable the system to compete in the logistics sector.

International Journal of Supply Chain, Operation Management and Logistics
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IJSCOL
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Keywords:

Freight Transport, Multimodal, Stated Preference, AHP, Generalized Cost.

Introduction

Freight transportation network in Indonesia, which is an archipelagic country with an area of 1,916,906.77 km^2 with 16,056 islands, is still not optimal (BPS, 2019). This is due to several factors such as the complexity of licensing, unreliable lead time due to mode shifts which are still dominated by 75.3% road transport, resulting in high logistics costs (Gurning, 2017; INDII, 2014). Therefore, it is necessary to have an alternative freight transportation network, namely multimodal which in Indonesia has not been effective. Considering the concept of a freight multimodal transportation network, it has been stated in Indonesian Ministerial Regulation No. 8 of 2012. Multimodal is the use of two or more modes such as road, rail and sea modes (Steadieseifi, Dellaert, Nuijten, Van Woensel, & Raoufi, 2014).

A freight network which use multimodal needs to be developed to support regional economic growth, and be able to reduce negative environmental impacts and energy consumption (Yamada, Russ, Castro, & Taniguchi, 2009). Observed from the consumer side, multimodal is also able to facilitate the delivery of goods considering that the delivery is based on door to door. So, it is required to develop an efficient freight transportation network after an area already has a multimodal transportation network to become intermodal transportation (Lubis & Sjafruddin, 2005).

Planning a multimodal freight transportation network needs to consider several variables. An important variable in effective and efficient multimodal system is the generalized cost variable. Generalized cost in transportation is a total cost concept which is a combination of three main components (time, distance and cost) to be converted into a certain value which can be a unit of cost or time (Anwar, Syapawi, & Ilham, 2008).

The goal of this paper is to analyze the generalized cost of multimodal freight transportation using the main modes (land, sea and train modes) based on factors from the perspective of business actors (freight forwarders and shippers). This paper is arranged in the following order: Section 2 describes the methodology that covers the entire research process along with data sources, the factors used in the generalized cost and stated preference monetization factors to determine the cost value of the generalized cost factor. Section 3 presents the results of the survey and the generalized cost model. Section 4 contains conclusions and suggestions for further research.

Literature Review

Multimodal Freight Transport

Freight transport involving at least two modes of transportation, based on single contract as a multimodal transport document, from a place where goods are received by a multimodal transport business entity to a place specified a location where goods are received by multimodal transport business entity to a location specified for delivery of goods to multimodal transport goods recipient (PP, 2012). Multimodal is a condition where the mode of transportation provides a travel network from origin to destination (door-to-door) (Rodrigue, Comtois, &

International Journal of Supply Chain, Operation Management and Logistics
EISSN: 2682-8685
IJSCOL
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Slack, 2016). The unit (size) of shipping goods can be in the form of containers, boxes, palletization or vehicles (Steadieseifi et al., 2014). There is some literature that discusses multimodal, especially in Indonesia by comparing multimodal policies in several countries such as Germany, Brazil and America in order to overcome obstacles for service providers and users so as to improve logistics performance (Budisiswanto, Miharja, Kombaitan, & Pradono, 2018). Logistics costs can be reduced by a multimodal system that is able to deliver goods efficiently and quickly (Wibowo & Chairuddin, 2017).

Factors Affecting Freight Transport

The factors that influence the choice of modes are important for planning a competitive transportation system (Flöden, Bärthel, & Sorkina, 2010) and several studies have been carried out to determine the choice of multimodal transportation. The choice of mode is highly dependent on the commodity being sent, such as the speed factor (Punakivi & Hinkka, 2006). The main influencing factors are costs, network characteristics, commodity characteristics, quality, externalities, risk of loss or damage to goods (Meixell & Norbis, 2008). In 2003, the choice of mode in Belgium determined the factors that influence the choice of mode cost, flexibility, security and time are important variables (Vannieuwenhuyse, Gelders, & Pintelon, 2003). This research is in line with research (Konstantinus & Zuidgeest, 2019) which illustrates the importance of modal selection for multimodal for developing countries and regions.

Generalized Cost

Generalized cost modeling is used to minimize transportation costs. Generalized costs can be used in spatial modeling with variable approaches in the form of delivery size, speed, value density and economies of scale (Tavasszy, Davydenko, & Ruijgrok, 2009). Other research uses generalized cost in determining the minimum cost between multimodal and unimodal with factors that influence business actors to prefer multimodal (Sandberg, Hanssen, Mathisen, & Jorgensen, 2012). Research conducted in Aceh, Indonesia uses transportation costs that have been separated into vehicle operating costs, loading and unloading costs (Saleh & Sjafruddin, 2010). Cost savings based on research conducted in Indonesia on the Sea-Toll provides a good picture by monetizing the actual shipping costs with the time value of the type of cargo (Triantoro, 2020).

Methodology

Stated Preference (SP) is used to determine the monetization value of the variables used for generalized cost model analysis. The generalized cost model is obtained from the utility value of the analysis using the multinomial logit method. The data used in this study is based on the preferences of business actors (freight forwarders and shippers) in Java. The region was chosen considering that economic growth is still centered on the islands of Java based on the contribution to national GDP, namely 58.5% (BPS, 2017).

Analytical Hierarchy Process

The first step is to conduct a survey to find out the main factors that influence the choice of modes for generalized cost of freight transport. This study chooses six factors that are often used in some research which are describes in table 1

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Table 1: Definition Of Variables Use In This Research

Variables	Definition
Transport Cost	Cost of Shipping Goods from the Point of Destination or Door-to-Door Including Loading and Unloading Costs
Reliability	Level of Timeliness of Delivery
Lead Time	Time Required to Move 1 TEU from the Point of Origin to the Point of Destination where the Goods are Unloaded until They are Delivered to the Recipient/Owner.
Frequency	Frequency of Certain Modes of Service (i.e. the Frequency of Truck Modes in a Day)
Flexibility	Unschedule Deliveries that can be Carried Out while Delay
Level of Damage/Loss of Goods	A Condition of Changes to Goods during the Delivery Process

At this stage, the Analytical Hierarchy Process (AHP) method is used to obtain a representation of a complex problem in a multilevel structure where there are objectives, factors, sub-criteria and alternatives (Saaty, 1993).

The results obtained from the survey of mode selection factor analysis were analyzed using Expert Choice software. This analysis aims to obtain the results of the most influential factors from the largest AHP value obtained. These factors were selected based on factors that are often used in mode selection studies which are summarized in the table 2.

Table 2: Mode Choice Factors from References

Reference	Mode	Variables
Cullinane and Toy (2000)	-	Transport Cost, Reliability, Lead Time and Item Characteristics
Shinghal and Fowkeys (2002)	Road and Rail	Reliability and Flexibility
Norojono and Young (2003)	Road and Rail	Reliability, Flexibility and Security
Garcia – Menendez et al (2004)	Sea and Road	Transport Cost, Flexibility and Lead Time
Beuthe and Bouffioux (2008)	Road, Rail and Inland Waterways	Transport Cost, Reliability and Lead Time
Feo-Valero et al (2011)	Road and Rail	Transport Cost, Reliability, Flexibility, Lead Time, Frequency, Level of Damage/Loss of Items
Brooks et al (2012)	Road, Rail and Maritime	Transport Cost, Reliability and Lead Time
Ravibabu (2013)	-	Transport Cost and Lead Time

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Reis (2014)	Road and Rail	Transport Cost, Reliability and Lead Time
Tri Nugroho (2016)	Road and Rail	Transport Cost, Reliability, Lead Time and Frequency

Source: (Beuthe & Bouffioux, 2008; Brooks, Puckett, Hensher, & Sammons, 2012; Cullinane & Toy, 2000; Feo-Valero, Garcia-Menendez, & Hidalgo, 2011; Garcia-Menendez, Martinez-Zarzoso, & Miguel, 2004; Manchala, 2013; Norojono & Young, 2003; Nugroho, 2016; Reis, 2014; Shinghal & Fowkes, 2002)

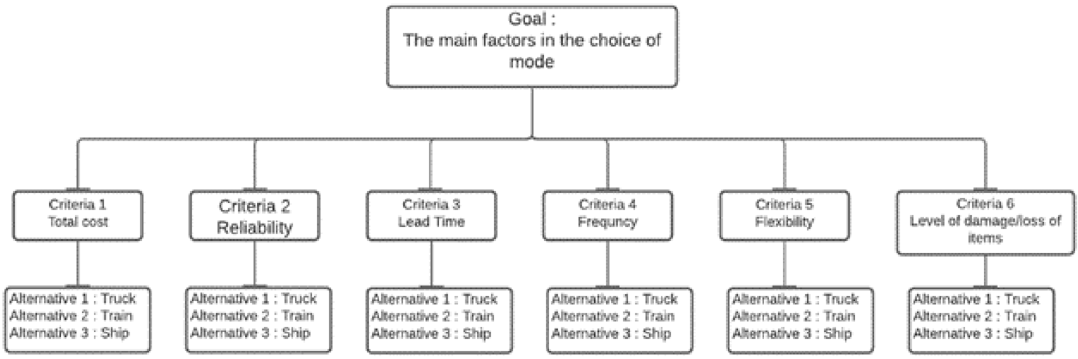

Figure 1: Hierarchy Structure of Mode Choice Analysis

Table 3: AHP Scale and Definition

Scale	Importance
1	Equal Importance
3	Slightly More Importance
5	Materially More Importance
7	Significantly More Importance
9	Absolutely More Importance
2,4,6,8	Compromise Value

Source: (Saaty, 1993)

Stated Preference

The second stage is the making of a stated SP survey based on the most influential factors in the analysis from the first stage. This survey aims to determine the monetization value of the factors that are considered influential. The results of this survey were then analyzed using NLOGIT version 6 software using the multinomial logit method. The multinomial logit method generated from several specified modes truck, train and ship modes, produces a utility model. The utility model obtained is the model used for generalized cost.

SP used is a choice modeling category in the form of a discrete choice model. The model is able to facilitate calculations in monetizing the analyzed factors in the form of costs (money). Based on the preliminary survey, it was found that the Jakarta - Surabaya route has 3 modes of transporting goods (trucks, trains and ships) so it is used as a hypothetical condition shows in Table 4

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EISSN: 2682-8685
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Table 4: Hypothetical Conditions of Each Modes

	Transport Cost	Lead Time	Reliability
Truck	Rp 13,000,000	24 Hours	80% On Time
Train	Rp 10,000,000	16 Hours	90% On Time
Ship	Rp 5,750,000	120 Hours	70% On Time

The attributes and levels used in this study for each mode are listed in the Table 5

Table 5: Attributes Level of Each Variables Modes

	Truck			**Train**			**Ship**		
Attributes	**Level 1**	**Level 2**	**Level 3**	**Level 1**	**Level 2**	**Level 3**	**Level 1**	**Level 2**	**Level 3**
Transport Cost	-2	Existing	+2	-2	Existing	+2	-1	Existing	+1
Lead Time	+5	Existing	-5	+3	Existing	-3	+24	Existing	-24
Reliability	%20 On Time	40% On Time	80% On Time	20% On Time	40% On Time	80% On Time	20% On Time	40% On Time	80% On Time

Based on the original orthogonal design, the combination was 3^3 where there were 3 factors that resulted in 27 combinations. To reduce respondents' confusion and fatigue, the alternatives were simplified to 9 combinations. This simplification uses a full factorial design with each level in which in this study there are 3 levels for each attribute (variable) of transport cost, lead time and reliability combined for each other level for each other attribute. It can summarize all the main conditions and interactions between variables in the dataset.

Comparative Analysis

The third stage presents a comparative analysis between generalized cost models from several modes and then provides conclusions regarding the generalized cost model for truck, rail and ship modes. The analysis is used to see the current condition of Indonesia's multimodal and determine which modes should be further developed.

Model Development

Based on a survey conducted on 36 business actors with the location of destination and origin of goods in Java. The choice of SP survey data is then converted into binary data using the Multinomial Logit model. The model will provide input in the form of a utility model where there are two variables consisting of a random component (ε) an observed component (V) (McFadden, 1974; Thurstone, 1927).

$$U = V + \varepsilon$$

The deterministic component of the utility function can be written as follows

$$V_{in} = b_1 X_{in1} + b_2 X_{IN2} + \ldots + b_k X_{ink}$$

Where

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V_{in} deterministic component of utility function
$b_1, b_2, \ldots, b_n$ parameter associated to attributes
$X_{in1}, X_{in2}, \ldots, X_{ink}$ attributes explained alternatives

The following is a generalized cost based on the utility function

$$U = a\,(\text{Transport cost}) + b\,(\text{Lead time}) + g(\text{Reliability}) + \varepsilon$$

Where:

Transport cost, lead time and reliability are trip attributes and a, b, g are attributes' coefficients. Unit changes or monetization can be obtained based on the coefficient obtained, the value of lead time (VOT) = b/a and value of reliability (VOR) = g/a. The generalized cost model is the number of attributes that are converted into certain units in this study is cost (Indonesian rupiah) from origin i to destination j which can be stated as follows

$$C_{ij} = F_{ij} + a_1\, tt_{ij} + a_2\, r_{ij}$$

Where C_{ij} = Generalized cost from i to j
F_{ij} = Transport cost door to door from i to j
$a_1\, tt_{ij}$ = Lead time monetization of cost from i to j
$a_2\, r_{ij}$ = Reliability monetization of cost from i to j

Table 6: Utility Function of Each Modes

Truck	**U = -0.25092 X1 – 0.04368 X2 – 0.29653 X3 – 0.25417**
Train	U = -0.37835 X1 – 0.06212 X2 – 0.37831 X3 + 0.19765
Ship	U = -0.09539 X1 – 0.00843 X2 – 0.03487 X3 + 0.54543

Result and Discussion

AHP Analysis

Survey was conducted on 19 Freight Forwarders and 17 Shippers who have authority to make decision-making in Java with various commodities. Commodities shipped are grouped into several sub-commodities such as bulk, general customer goods, special commodities and others. In Figure 2 it can be seen the results of the AHP analysis, the results are said to be consistent when the consistency ratio (CI) value is close to zero (Suryadi, Ramdhani, & Anisah, 2000). Of all the criteria and alternatives in Figure 2 AHP has a consistent CI, namely 0.00201 transport cost; 0.01 lead time; 0.01 reliability; 0.03 frequncy; 0.04 flexibility and 0.01 level of damage/loss of goods.

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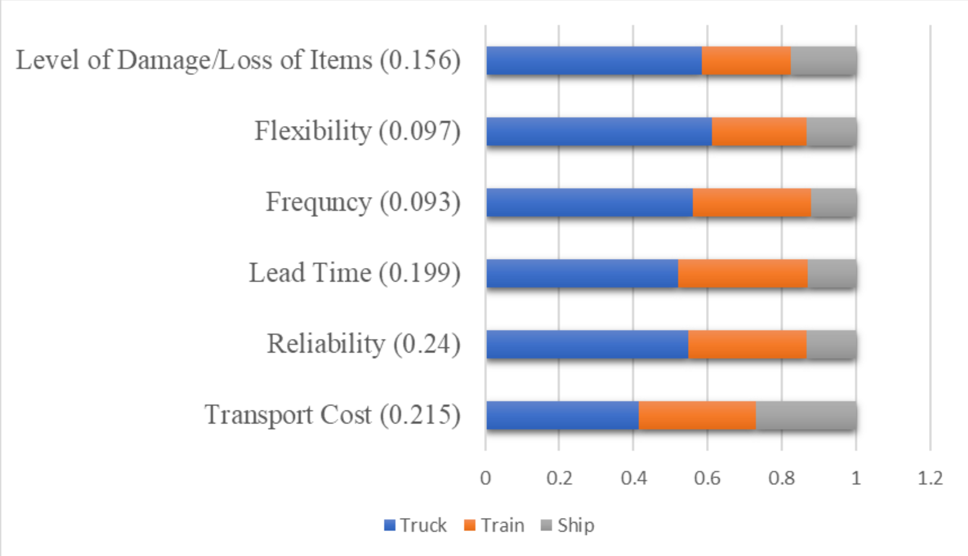

Figure 2: AHP Analysis Result

Based on figure 2, it can be seen that the largest proportion is in the criteria of reliability (0.240), transport cost (0.215) and lead time (0.199). These results are in line with the reasons of the respondents who are people directly related to the process of selecting modes in logistics activities. Where the reliability factor (timeliness) is crucial considering that delays in delivery of goods can increase lead time which adds to shipping costs which are part of the transport cost. Based on the results of interviews with several business agent, different raw materials do not significantly influence the choice of factors in the choice of transport mode.

The alternatives obtained from the survey results are still dominated by the modes of trucks (0.583), trains (0.240) and ships (0.176). This is in accordance with the current condition of selecting the mode of transportation of goods in Indonesia, which is still dominated by the truck mode, which has high transportation and infrastructure costs, and frequent accidents and congestions. In Indonesia, the average proportion of travel by road mode dominates 75.3%, train 1.1% and ship mode 24.2% (INDII, 2014). Therefore, it is necessary to optimize the use of multimodal in Indonesia considering the condition of the mode used is still focused on road modes to maximize the potential of national logistics of an archipelago country.

In Table 7 it can be seen that the estimates of the variables are in accordance with what is expected in actual conditions. Test the whole model by looking at the comparison of the chi-square count that is greater than the chi-square table. Test the influence factor with a z value to determine the order of the most influential factors based on a significance value of 5%. The coefficient in the negative value model indicates that an increase in each variable will decrease utility or decrease a person's willingness to choose an alternative.

Table 7*: Parameter Result of Multinomial Logit Model*

Attributes	**Coefficient**			**Prob z> Z***		
	Truck	Train	Ship	Truck	Train	Ship
Travel Cost	-0.25092	-0.37835	-0.09539	0.0002	0.0006	0.5787
Lead Time	-0.04368	-0.06212	-0.00843	0.1038	0.3428	0.3181
Reliability	-0.29653	-0.37831	-0.03487	0.0003	0.0032	0.0001
Log – L0 Truck			-128.109			

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	Train	-62.383
	Ship	-73.9499
Log - L	Truck	-117.6522
	Train	-53.132
	Ship	-62.00561
Chi-Squared	Truck	20.91369
	Train	18.50194
	Ship	23.88863
Chi–Squared Table	Truck	7.8147
	Train	7.8147
	Ship	7.8147

Table 8: VOT and VOR Result

	a	b	g	Lead Time (VOT)		Reliability (VOR)	
				Rupiah (Juta)/ Hour	**USD/Hour**	**Rupiah (Juta)/ Hour**	**USD/Hour**
Truck	-0.25092	-0.04368	-0.29653	174,079	12	1,181,771	82
Train	-0.37835	-0.06212	-0.37831	164,187	11	999,894	69
Ship	-0.09539	-0.00843	-0.03487	88,374	6	365,552	25

Table 9*:* Generalized Cost for Each Modes

	Transport Cost	Lead Time (VOT)	Reliability (VOR)	Generalized Cost (GC)
Truck	13,000,000	174,079	1,181,771	22,850,407
Train	10,000,000	164,187	999,894	14,226,816
Ship	5,750,000	88,374	365,552	29,514,755

Case Study

In this calculation, transportation costs, lead time and reliability are used by calculating the hours of delay based on the percentage of on-time shipments from Jakarta - Surabaya. The value of the lead time (VOT) parameter in the vehicle to the cost per hourly delivery is Rp. 174,079 for truck mode, Rp. 164,187 for train mode and Rp. 88,374 for ship mode. The value of reliability (VOR) on the cost per delivery per hour is IDR 1,181,771 for truck mode, IDR 999,894 for train mode and IDR 365,552 for ship mode. These results indicate that business actors in the truck mode are willing to pay Rp. 174,079 per delivery to be able to save time for one hour while they are willing to pay Rp. 1,181,771 per delivery to reduce the variance of lead time in the form of a delay of one hour.

There are differences in the preference for reducing the time variance from one mode to another. The truck mode according to its characteristics has a high level of delay due to congestion or other obstacles such as the absence of adequate infrastructure. This is different from other modes such as trains where there are still few available rails in certain areas and sea modes which take a long time due to depending on unpredictable weather conditions.

Basically there are many factors that affect lead time (Kumar, Basu, & Maitra, 2004). Where in freight transport, the lead time is influenced by the cost of the trip, the commodity sent and the route taken.

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EISSN: 2682-8685
IJSCOL
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Conclusion

In optimizing the multimodal freight transport in Indonesia, it is important to know the factors that influence business actors in choosing modes. Based on the choice of business actors, it was found that the influencing factors were transport cost, lead time and reliability with alternative modes of trucks, trains and ships. This study further used these factors to develop a utility model of the modes of trucks, trains and ships. The VOT and VOR values of trucks are still the highest compared to other modes of Rp. 174,079 per delivery per hour and Rp. 1,181,771 per delivery per hour respectively. But considering the long lead time and the low level of reliability of ships, the value of the largest Generalized cost is in the ship mode, which is Rp. 29,514,755.

Limitations in this study can be developed for further research. The expansion of the wider scope will provide a more valid picture of the logistics conditions in Indonesia. The use of other monetization factors such as frequency, flexibility and the level of damage or loss of goods is certainly able to provide a better picture of the Generalized Cost, especially for different commodities. So that it can be used as a reference in determining future transportation policies made by the government. Policies that are right on target are expected to increase competitiveness in the logistics sector.

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International Journal of Supply Chain, Operation Management and Logistics
EISSN: 2682-8685
IJSCOL
Volume 3 Issue 5 (March 2022) PP. 14-25
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